

specified in §178.345-3 of this subpart are not exceeded. In no case may the shell or head thickness be less than that specified in the applicable specification.

(c) *Corrosion or abrasion protection.* When required by 49 CFR part 173 for a particular lading, a cargo tank or a part thereof, subject to thinning by corrosion or mechanical abrasion due to the lading, must be protected by providing the tank or part of the tank with a suitable increase in thickness of material, a lining or some other suitable method of protection.

(1) *Corrosion allowance.* Material added for corrosion allowance need not be of uniform thickness if different rates of attack can reasonably be expected for various areas of the cargo tank.

(2) *Lining.* Lining material must consist of a nonporous, homogeneous material not less elastic than the parent metal and substantially immune to attack by the lading. The lining material must be bonded or attached by other appropriate means to the cargo tank wall and must be imperforate when applied. Any joint or seam in the lining must be made by fusing the materials together, or by other satisfactory means.

[Amdt. 178-89, 54 FR 25021, June 12, 1989, as amended at 55 FR 37059, Sept. 7, 1990; 56 FR 27876, June 17, 1991; Amdt. 178-97, 57 FR 45465, Oct. 1, 1992; Amdt. 178-118, 61 FR 51341, Oct. 1, 1996]

§ 178.345-3 Structural integrity.

(a) *General requirements and acceptance criteria.* (1) The maximum calculated design stress at any point in the cargo tank wall may not exceed the maximum allowable stress value prescribed in section VIII of the ASME Code, or 25 percent of the tensile strength of the material used at design conditions.

(2) The relevant physical properties of the materials used in each cargo tank may be established either by a certified test report from the material manufacturer or by testing in conformance with a recognized national standard. In either case, the ultimate tensile strength of the material used in the design may not exceed 120 percent of the minimum ultimate tensile strength

specified in either the ASME Code or the ASTM standard to which the material is manufactured.

(3) The maximum design stress at any point in the cargo tank must be calculated separately for the loading conditions described in paragraphs (b) and (c) of this section. Alternate test or analytical methods, or a combination thereof, may be used in place of the procedures described in paragraphs (b) and (c) of this section, if the methods are accurate and verifiable.

(4) Corrosion allowance material may not be included to satisfy any of the design calculation requirements of this section.

(b) *ASME Code design and construction.* The static design and construction of each cargo tank must be in accordance with Section VIII, Division 1 of the ASME Code. The cargo tank design must include calculation of stresses generated by the MAWP, the weight of the lading, the weight of structures supported by the cargo tank wall and the effect of temperature gradients resulting from lading and ambient temperature extremes. When dissimilar materials are used, their thermal coefficients must be used in the calculation of thermal stresses.

(1) Stress concentrations in tension, bending and torsion which occur at pads, cradles, or other supports must be considered in accordance with Appendix G of Section VIII, Division 1 of the ASME Code.

(2) Longitudinal compressive buckling stress for ASME certified vessels must be calculated using paragraph UG-23(b), Section VIII, Division 1 of the ASME Code. For cargo tanks not required to be certified in accordance with the ASME Code, compressive buckling stress may be calculated using alternative analysis methods which are accurate and verifiable. When alternative methods are used calculations must include both the static loads described in this paragraph and the dynamic loads described in paragraph (c) of this section.

(c) *Shell design.* Shell stresses resulting from static or dynamic loadings, or combinations thereof, are not uniform throughout the cargo tank motor vehicle. The vertical, longitudinal, and lateral normal operating loadings can

occur simultaneously and must be combined. The vertical, longitudinal and lateral extreme dynamic loadings occur separately and need not be combined.

(1) *Normal operating loadings.* The following procedure addresses stress in the cargo tank shell resulting from normal operating loadings. The effective stress (the maximum principal stress at any point) must be determined by the following formula:

$$S = 0.5(S_y + S_x) \pm [0.25(S_y - S_x)^2 + S_s^2]^{0.5}$$

Where:

(i) S = effective stress at any given point under the combination of static and normal operating loadings that can occur at the same time, in psi.

(ii) S_y = circumferential stress generated by the MAWP and external pressure, when applicable, plus static head, in psi.

(iii) S_x = The following net longitudinal stress generated by the following static and normal operating loading conditions, in psi:

(A) The longitudinal stresses resulting from the MAWP and external pressure, when applicable, plus static head, in combination with the bending stress generated by the static weight of the fully loaded cargo tank motor vehicle, all structural elements, equipment and appurtenances supported by the cargo tank wall;

(B) The tensile or compressive stress resulting from normal operating longitudinal acceleration or deceleration. In each case, the forces applied must be 0.35 times the vertical reaction at the suspension assembly, applied at the road surface, and as transmitted to the cargo tank wall through the suspension assembly of a trailer during deceleration; or the horizontal pivot of the truck tractor or converter dolly fifth wheel, or the drawbar hinge on the fixed dolly during acceleration; or anchoring and support members of a truck during acceleration and deceleration, as applicable. The vertical reaction must be calculated based on the static weight of the fully loaded cargo tank motor vehicle, all structural elements, equipment and appurtenances supported by the cargo tank wall. The following loadings must be included:

(1) The axial load generated by a decelerative force;

(2) The bending moment generated by a decelerative force;

(3) The axial load generated by an accelerative force; and

(4) The bending moment generated by an accelerative force; and

(C) The tensile or compressive stress generated by the bending moment resulting from normal operating vertical accelerative force equal to 0.35 times the vertical reaction at the suspension assembly of a trailer; or the horizontal pivot of the upper coupler (fifth wheel) or turntable; or anchoring and support members of a truck, as applicable. The vertical reaction must be calculated based on the static weight of the fully loaded cargo tank motor vehicle, all structural elements, equipment and appurtenances supported by the cargo tank wall.

(iv) S_s = The following shear stresses generated by the following static and normal operating loading conditions, in psi:

(A) The static shear stress resulting from the vertical reaction at the suspension assembly of a trailer, and the horizontal pivot of the upper coupler (fifth wheel) or turntable; or anchoring and support members of a truck, as applicable. The vertical reaction must be calculated based on the static weight of the fully loaded cargo tank motor vehicle, all structural elements, equipment and appurtenances supported by the cargo tank wall;

(B) The vertical shear stress generated by a normal operating accelerative force equal to 0.35 times the vertical reaction at the suspension assembly of a trailer; or the horizontal pivot of the upper coupler (fifth wheel) or turntable; or anchoring and support members of a truck, as applicable. The vertical reaction must be calculated based on the static weight of the fully loaded cargo tank motor vehicle, all structural elements, equipment and appurtenances supported by the cargo tank wall;

(C) The lateral shear stress generated by a normal operating lateral accelerative force equal to 0.2 times the vertical reaction at each suspension assembly of a trailer, applied at the road surface, and as transmitted to the

cargo tank wall through the suspension assembly of a trailer, and the horizontal pivot of the upper coupler (fifth wheel) or turntable; or anchoring and support members of a truck, as applicable. The vertical reaction must be calculated based on the static weight of the fully loaded cargo tank motor vehicle, all structural elements, equipment and appurtenances supported by the cargo tank wall; and

(D) The torsional shear stress generated by the same lateral forces as described in paragraph (c)(1)(iv)(C) of this section.

(2) *Extreme dynamic loadings.* The following procedure addresses stress in the cargo tank shell resulting from extreme dynamic loadings. The effective stress (the maximum principal stress at any point) must be determined by the following formula:

$$S = 0.5(S_y + S_x) \pm [0.25(S_y - S_x)^2 + S_s^2]^{0.5}$$

Where:

(i) S = effective stress at any given point under a combination of static and extreme dynamic loadings that can occur at the same time, in psi.

(ii) S_y = circumferential stress generated by MAWP and external pressure, when applicable, plus static head, in psi.

(iii) S_x = the following net longitudinal stress generated by the following static and extreme dynamic loading conditions, in psi:

(A) The longitudinal stresses resulting from the MAWP and external pressure, when applicable, plus static head, in combination with the bending stress generated by the static weight of the fully loaded cargo tank motor vehicle, all structural elements, equipment and appurtenances supported by the tank wall;

(B) The tensile or compressive stress resulting from extreme longitudinal acceleration or deceleration. In each case the forces applied must be 0.7 times the vertical reaction at the suspension assembly, applied at the road surface, and as transmitted to the cargo tank wall through the suspension assembly of a trailer during deceleration; or the horizontal pivot of the truck tractor or converter dolly fifth wheel, or the drawbar hinge on the fixed dolly during acceleration; or the

anchoring and support members of a truck during acceleration and deceleration, as applicable. The vertical reaction must be calculated based on the static weight of the fully loaded cargo tank motor vehicle, all structural elements, equipment and appurtenances supported by the cargo tank wall. The following loadings must be included:

(1) The axial load generated by a decelerative force;

(2) The bending moment generated by a decelerative force;

(3) The axial load generated by an accelerative force; and

(4) The bending moment generated by an accelerative force; and

(C) The tensile or compressive stress generated by the bending moment resulting from an extreme vertical accelerative force equal to 0.7 times the vertical reaction at the suspension assembly of a trailer, and the horizontal pivot of the upper coupler (fifth wheel) or turntable; or the anchoring and support members of a truck, as applicable. The vertical reaction must be calculated based on the static weight of the fully loaded cargo tank motor vehicle, all structural elements, equipment and appurtenances supported by the cargo tank wall.

(iv) S_s = The following shear stresses generated by static and extreme dynamic loading conditions, in psi:

(A) The static shear stress resulting from the vertical reaction at the suspension assembly of a trailer, and the horizontal pivot of the upper coupler (fifth wheel) or turntable; or anchoring and support members of a truck, as applicable. The vertical reaction must be calculated based on the static weight of the fully loaded cargo tank motor vehicle, all structural elements, equipment and appurtenances supported by the cargo tank wall;

(B) The vertical shear stress generated by an extreme vertical accelerative force equal to 0.7 times the vertical reaction at the suspension assembly of a trailer, and the horizontal pivot of the upper coupler (fifth wheel) or turntable; or anchoring and support members of a truck, as applicable. The vertical reaction must be calculated based on the static weight of the fully loaded cargo tank motor vehicle, all

structural elements, equipment and appurtenances supported by the cargo tank wall;

(C) The lateral shear stress generated by an extreme lateral accelerative force equal to 0.4 times the vertical reaction at the suspension assembly of a trailer, applied at the road surface, and as transmitted to the cargo tank wall through the suspension assembly of a trailer, and the horizontal pivot of the upper coupler (fifth wheel) or turntable; or anchoring and support members of a truck, as applicable. The vertical reaction must be calculated based on the static weight of the fully loaded cargo tank motor vehicle, all structural elements, equipment and appurtenances supported by the cargo tank wall; and

(D) The torsional shear stress generated by the same lateral forces as described in paragraph (c)(2)(iv)(C) of this section.

(d) In no case may the minimum thickness of the cargo tank shells and heads be less than that prescribed in § 178.346-2, § 178.347-2, or § 178.348-2, as applicable.

(e) For a cargo tank mounted on a frame or built with integral structural supports, the calculation of effective stresses for the loading conditions in paragraph (c) of this section may include the structural contribution of the frame or the integral structural supports.

(f) The design, construction, and installation of an appurtenance to the cargo tank must conform to the following requirements:

(1) Structural members, the suspension subframe, accident protection and external rings must be used as sites for attachment of appurtenances and other accessories to the cargo tank, when practicable.

(2) A lightweight attachment to the cargo tank wall, such as a conduit clip, brakeline clip, skirting structure, lamp mounting bracket, or placard holder, must be of a construction having lesser strength than the cargo tank wall materials and may not be more than 72 percent of the thickness of the material to which it is attached. The lightweight attachment may be secured directly to the cargo tank wall if the device is designed and installed in such a

manner that, if damaged, it will not affect the lading retention integrity of the tank. A lightweight attachment must be secured to the cargo tank shell or head by continuous weld or in such a manner as to preclude formation of pockets, which may become sites for incipient corrosion.

(3) Except as prescribed in paragraphs (f)(1) and (f)(2) of this section, the welding of any appurtenance to the cargo tank wall must be made by attachment of a mounting pad, so that there will be no adverse effect upon the lading retention integrity of the cargo tank if any force less than that prescribed in § 178.345-8(b)(1) of this subchapter is applied from any direction. The thickness of the mounting pad may not be less than that of the shell or head to which it is attached, and not more than 1.5 times the shell or head thickness. However, a pad with a minimum thickness of 0.187 inch may be used when the shell or head thickness is over 0.187 inch. If weep holes or tell-tale holes are used, the pad must be drilled or punched at its lowest point before it is welded. Each pad must—

(i) Extend at least 2 inches in each direction from any point of attachment of an appurtenance;

(ii) Have rounded corners, or otherwise be shaped in a manner to minimize stress concentrations on the shell or head; and

(iii) Be attached by a continuous weld around the pad except for a small gap at the lowest point for draining.

[Amdt. 178-89, 55 FR 37059, Sept. 7, 1990, as amended by Amdt. 178-89, 56 FR 27876, June 17, 1991; Amdt. 178-104, 59 FR 49135, Sept. 26, 1994; Amdt. 178-105, 59 FR 55173, 55174 and 55175, Nov. 3, 1994; 60 FR 17402, Apr. 5, 1995; Amdt. 178-118, 61 FR 51341, Oct. 1, 1996; 65 FR 58631, Sept. 29, 2000]

§ 178.345-4 Joints.

(a) All joints between the cargo tank shell, heads, baffles, baffle attaching rings, and bulkheads must be welded in conformance with the ASME Code welding procedures.

(b) Where practical all welds must be easily accessible for inspection.

[Amdt. 178-89, 54 FR 25022, June 12, 1989, as amended by Amdt. 178-118, 61 FR 51341, Oct. 1, 1996]